Crossflow instability in rotor-stator flows with throughflow

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We study the formation of new spiral patterns, denoted SRJ2 (figure 1(a)), at the periphery of an enclosed rotor-stator cavity when an axial inward or outward throughflow is superimposed.

Figure 1(b) shows the transition diagrams, obtained from flow visualizations, for three different aspect ratios $G = h/R_2$ in the (Re, V_z^*) plane, where h is the interdisk space, R_2 the rotating disk radius, Re the rotational Reynolds number and V_z^* the dimensionless axial velocity in the radial gap between the rotor and the shroud. Thus, the results of Poncet and Chauve [1] and Rémy *et al.* [2] have been extended for both Batchelor ($G = 0.0857$) and torsional Couette ($G = 0.0171$) type of flows. The SRJ2 spiral rolls appear essentially when an inward throughflow ($V_z^* > 0$) is superimposed but also in the case of an outward throughflow ($V_z^* < 0$) for $G = 0.0857$. Numerical calculations have shown that these structures appear as soon as a strong axial upward flow is created along the shroud, which may be the case when the outward throughflow impinges on the shroud. As the axial velocity profiles exhibit inflexion points, this instability is of crossflow type. From visualizations and velocity measurements, we have determined that these are positive spirals located at the periphery of the cavity along the stator side and characterized by small frequency and phase velocity and large inclination angle and azimuthal wavenumber. The influence of the flow control parameters Re, V_z^* and G on these characteristics have been analysed. There is a strong competition between rotation and throughflow. Nevertheless, the effects of the geometry G and of the throughflow V_z^* seem to be preponderant to be compared to the one of the rotation Re.

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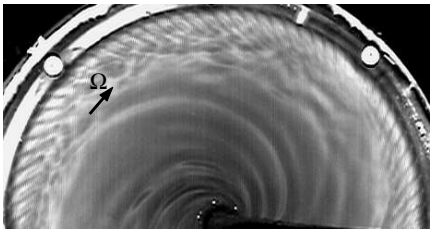
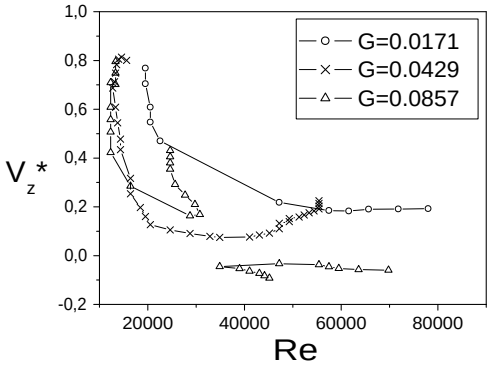
[1]Poncet and Chauve, *J. Fluid Mech.* **545**, 281 (2005).

[2]Rémy *et al.*, *Phys. Fluids* **17 (1)** (2005).



(a)



(b)

Figure 1: (a) Visualization of the SRJ2 patterns for $Re = 2.05 \times 10^4$, $V_z^* = 0.515$ and $G = 0.0429$. (b) Existence domains of the SRJ2 spirals in the (Re,V_z^*) plane.